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DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC-9015

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

MOGULS SCORING RECORD NO. 579

SITE LOCATION:
U.S. ARMY YUMA PROVING GROUND

DEMONSTRATOR:
G-TEK AUSTRALIA PTY LIMITED
3/10 HUDSON ROAD
ALBION QLD 4010 AUSTRALIA

TECHNOLOGY TYPE/PLATFORM:
TM-5 EMU/SLING

PREPARED BY:
U.S. ARMY ABERDEEN TEST CENTER
ABERDEEN PROVING GROUND, MD 21005-5059

JUNE 2005

Prepared for:
U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MD 21010-5401

U.S. ARMY DEVELOPMENTAL TEST COMMAND
ABERDEEN PROVING GROUND, MD 21005-5055

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14. ABSTRACT
This scoring record documents the efforts of G-TEK to detect and discriminate inert unexploded ordnance (UXO) utilizing the YPG Standardized UXO Technology Demonstration Site Mogul. The scoring record was coordinated by Larry Overbay and the Standardized UXO Technology Demonstration Site Scoring Committee. Organizations on the committee include the U.S. Army Corps of Engineers, the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program, the Institute for Defense Analysis, the U.S. Army Environmental Center, and the U.S. Army Aberdeen Test Center.

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SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND

Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland and U.S. Army Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the U.S. Army Environmental Center (AEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP) and the Army Environmental Quality Technology Program (EQT).

1.2 SCORING OBJECTIVES

The objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities of a given technology under various field and soil conditions. Inert munitions and clutter items are positioned in various orientations and depths in the ground.

The evaluation objectives are as follows:

a. To determine detection and discrimination effectiveness under realistic scenarios that vary targets, geology, clutter, topography, and vegetation.

b. To determine cost, time, and manpower requirements to operate the technology.

c. To determine demonstrator's ability to analyze survey data in a timely manner and provide prioritized "Target Lists" with associated confidence levels.

d. To provide independent site management to enable the collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

1.2.1 Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating

characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}), and those that do not correspond to any known item, termed background alarms.

b. The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the blind grid RESPONSE STAGE, the demonstrator provides the scoring committee with a target response from each and every grid square along with a noise level below which target responses are deemed insufficient to warrant further investigation. This list is generated with minimal processing and, since a value is provided for every grid square, will include signals both above and below the system noise level.

c. The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such and to reject clutter. For the blind grid DISCRIMINATION STAGE, the demonstrator provides the scoring committee with the output of the algorithms applied in the discrimination-stage processing for each grid square. The values in this list are prioritized based on the demonstrator's determination that a grid square is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking is based on human (subjective) judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e. that is expected to retain all detected ordnance and rejects the maximum amount of clutter).

d. The demonstrator is also scored on EFFICIENCY and REJECTION RATIO, which measures the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. EFFICIENCY measures the fraction of detected ordnance retained after discrimination, while the REJECTION RATIO measures the fraction of false alarms rejected. Both measures are defined relative to performance at the demonstrator-supplied level below which all responses are considered noise, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

e. Based on configuration of the ground truth at the standardized sites and the defined scoring methodology, there exists the possibility of having anomalies within overlapping halos and/or multiple anomalies within halos. In these cases, the following scoring logic is implemented:

(1) In situations where multiple anomalies exist within a single R_{halo}, the anomaly with the strongest response or highest ranking will be assigned to that particular ground truth item.

(2) For overlapping R_{halo} situations, ordnance has precedence over clutter. The anomaly with the strongest response or highest ranking that is closest to the center of a particular ground truth item gets assigned to that item. Remaining anomalies are retained until all matching is complete.

(3) Anomalies located within any R_{halo} that do not get associated with a particular ground truth item are thrown out and are not considered in the analysis.

f. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 3.1.1.

1.2.2 Scoring Factors

Factors to be measured and evaluated as part of this demonstration include:

a. Response Stage ROC curves:

(1) Probability of Detection (P_d^{res}).

(2) Probability of False Positive (P_{fp}^{res}).

(3) Background Alarm Rate (BAR^{res}) or Probability of Background Alarm (P_{BA}^{res}).

b. Discrimination Stage ROC curves:

(1) Probability of Detection (P_d^{disc}).

(2) Probability of False Positive (P_{fp}^{disc}).

(3) Background Alarm Rate (BAR^{disc}) or Probability of Background Alarm (P_{BA}^{disc}).

c. Metrics:

(1) Efficiency (E).

(2) False Positive Rejection Rate (R_{fp}).

(3) Background Alarm Rejection Rate (R_{BA}).

d. Other:

(1) Probability of Detection by Size and Depth.

(2) Classification by type (i.e., 20-, 40-, 105-mm, etc.).

(3) Location accuracy.

(4) Equipment setup, calibration time and corresponding man-hour requirements.

(5) Survey time and corresponding man-hour requirements.

(6) Reacquisition/resurvey time and man-hour requirements (if any).

(7) Downtime due to system malfunctions and maintenance requirements.

1.3 STANDARD AND NONSTANDARD INERT ORDNANCE TARGETS

The standard and nonstandard ordnance items emplaced in the test areas are listed in Table 1. Standardized targets are members of a set of specific ordnance items that have identical properties to all other items in the set (caliber, configuration, size, weight, aspect ratio, material, filler, magnetic remanence, and nomenclature). Nonstandard targets are inert ordnance items having properties that differ from those in the set of standardized targets.

TABLE 1. INERT ORDNANCE TARGETS

Standard Type	Nonstandard (NS)
20-mm Projectile M55	20-mm Projectile M55
	20-mm Projectile M97
40-mm Grenades M385	40-mm Grenades M385
40-mm Projectile MKII Bodies	40-mm Projectile M813
BDU-28 Submunition	
BLU-26 Submunition	
M42 Submunition	
57-mm Projectile APC M86	
60-mm Mortar M49A3	60-mm Mortar (JPG)
	60-mm Mortar M49
2.75-inch Rocket M230	2.75-inch Rocket M230
	2.75-inch Rocket XM229
MK 118 ROCKEYE	
81-mm Mortar M374	81-mm Mortar (JPG)
	81-mm Mortar M374
105-mm HEAT Rounds M456	
105-mm Projectile M60	105-mm Projectile M60
155-mm Projectile M483A1	155-mm Projectile M483A
	500-lb Bomb

JPG = Jefferson Proving Ground
HEAT = high-explosive antitank

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

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2.1.2 System Description (provided by demonstrator)

a. Sensor System Description. The man portable TM-5 electromagnetic unit (EMU) consists of the following components:

Item	Manufacturer	Model
Magnetometer control module	G-TEK	TM-5 EMU MPX
Multi-period, transient electromagnetic (EM) sensors	Minelab Electronics	F1B2
DGPS (digital Global Positioning System)	Ashtech	Z-Extreme
Odometer	G-TEK	TM-4D

The TM-5 EMU detector system may be configured with one or two sensors measuring the transient EM response. In the application proposed, two sensors will be mounted in an array, oriented perpendicular to the survey direction and delivering a 1.2-meter swath width. In the dual-sensor mode, the TM-5 EMU is operated by a single person (fig. 1).

The TM-5 EMU interfaces with both industry standard real-time kinematic (RTK) DGPS and proprietary cotton thread based odometer systems, providing versatile positioning adaptable to varied terrain and vegetation conditions. The TM-5 EMU has been successfully used for over 5 years. The odometer remains the positioning technology of choice in adverse terrains; DGPS is preferred in open environments. Combined, they meet the requirements of most situations.

The TM-5 EMU user interface provides a continuous set of data quality monitors. Audio and graphic displays and alarms monitor sensor signal quality and position data quality. A key attribute of the TM-5 EMU is its virtual immunity to hot rocks.

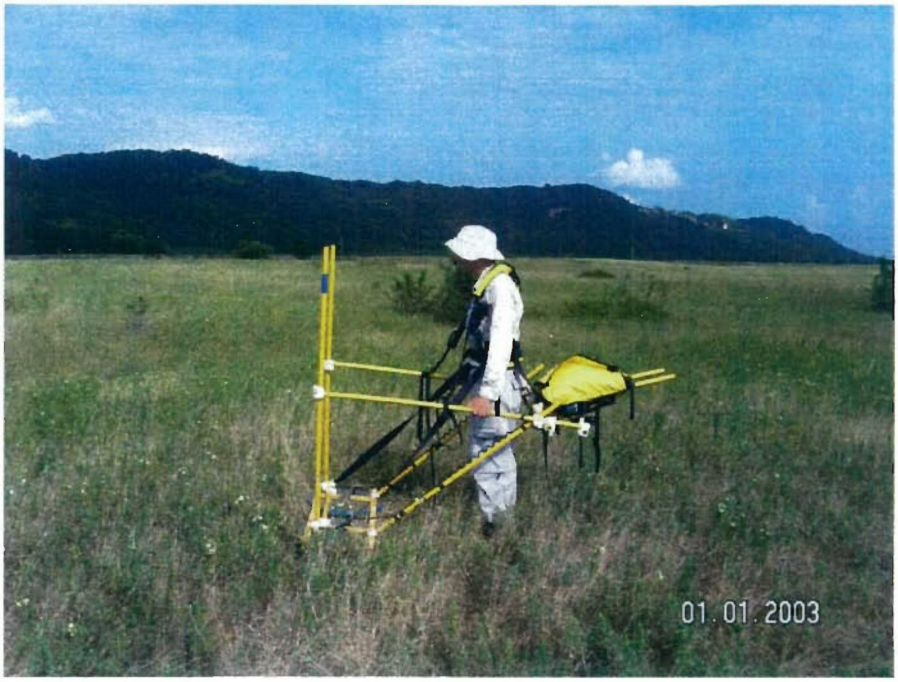


Figure 1. Demonstrator's system, TM-5 EMU (dual-sensor).

Prior to performing a survey, the TM-5 EMU undergoes the following three procedures, taking 5 minutes to complete all three: (1) Sensor pulse repetition frequency is swept over about 100 Hz, centered at 1200 Hz, to select the frequency corresponding to the lowest receiver root mean square (RMS) noise level, in order to minimize radio frequency (RF) interference. (2) Sensors are ground balanced to compute ground response parameters that are stored in memory so that the ground response may then be subtracted from the received signal in real-time. (3) A control source known as an EMUlator is used check that sensor signal levels are within specification.

The sensors are a monocoil acting as both transmitter and receiver, operated as a vertical magnetic dipole, with 16 turns, a diameter of 18 inches, inductance of 300 μH, and resistance of 0.7 Ω. During surveying, the sensor coil height is maintained at an elevation of 100 mm, with the minimum hazards of electromagnetic radiation to ordnance (HERO) safe operating height calculated to be 10 cm above ground.

The transmitted waveform consists of two different length pulses (20-μs, 3.3-A and 50-μs, 830-mA), repeated at the rate of approximately 1200 Hz. The peak pulse amplitudes are based on an application of 5 volts, and at turnoff, the pulses ramp to zero in about 2 to 4 μs (corresponding to the self-induced electromagnetic force (EMF) clipped to 187 volts). The theoretical bandwidth of about 500 kHz reduces to about 300 kHz after the addition of amplifiers and integrators. The detector is based on synchronous demodulation, sampling the secondary field decays over narrow integration gates. After subtracting the ground response and digitizing at approximately 60 Hz, the output is decimated to 32 samples per second that are recorded with

a DGPS position at a $\geq$1-Hz rate. Amplifier gains are adjusted to provide digital output between $\pm$ 4096 units such that background noise is set to $\pm$1 to 2 units. A low pass filter is applied at periodic intervals to reset the background signal to a zero mean. During a traverse, this filter is switched out so that the filter does not attenuate target responses, and the drift is removed from the digital record in post-processing with a high-pass filter.

b. Positioning System Description. G-TEK proposed using a combination of the following survey/navigation technologies:

Item	Manufacturer	Model
DGPS	Ashtech	Z-Extreme
Odometer	G-TEK	TM-4D
Polychain	PEKO	100M
Sighters	Various	Generic traffic cones; wooden dowels and flagging.

The TM-5 EMU detector system interfaces with both industry standard RTK DGPS and proprietary cotton thread based odometer systems, providing versatile time or position-based positioning that is adaptable to varied terrain and vegetation conditions. In both cases, where UXO detection standards of survey coverage are required, G-TEK operators use a pre-established control grid and visual sighters for straight-line navigation, and the DGPS or odometer for data positioning only.

2.1.2.1 Using DGPS in the Open Area. DGPS is the technology of choice in situations where satellite coverage is reliable. In this case, any of the industry standard RTK systems (with the precise 1-pulse-per-second facility) may be used, although in this program we propose using the Ashtech Z-Extreme system (with NovAtel RT-2 as a backup). The preference is to establish a Global Positioning System (GPS) base station on a monument that is within 1 km of the survey area and to use a radio link to the roving GPS receiver. In the roving instrumentation, sensor data are merged, synchronized with the transformed DGPS positions, and recorded. In this way, sensor data are positioned with an accuracy of better than 5 cm. Prior to commencing the survey, the roving GPS is located at a known reference to confirm the integrity of the system and transformations used. The real-time DGPS will be used to establish a control grid using non-metallic pegs at intervals appropriate to the level of visibility. At YPG a control line interval of 25 or 50 meters is anticipated. The non-metallic polychains will then be laid as control lines, perpendicular to the proposed survey direction. Visual sighters will be located along the first survey line and used as a visual aid to navigation. As each sighter is reached, it will be moved 0.8 meters laterally to the position of the return survey line.

2.1.2.2 Using the Odometer in the Wooded Area. The control grid setup combines the use of DGPS and cotton odometer survey techniques. Navigation is done the same as described above. However, 5 meters before the commencement of each new transect, the cotton thread is tied to either vegetation or a small peg anchored to the ground. When each control line is reached, a distance mark is recorded in the TM-5 EMU prior to moving the cone. At the completion of each survey grid section, the cotton is gathered and removed from the site. In

post-processing, linear error distribution delivers positional accuracy that is typically less than 0.1 percent of the distance between control lines (0.1 percent of 25 meters delivers 2.5 cm accuracy in this case). Because the odometer is used in more adverse terrain, including forests, protocols have been developed using the electronic notepad facility of the TM-5 EMU for recording the location of obstacles (e.g., trees) and the direction taken around them. If a UXO is detected close to a tree, the validation team will know which side of the tree to search. Experience over many years surveying in forested conditions has indicated that an rms target position error of less than 30 mm can be anticipated with the greatest errors occurring where obstacles are circumvented. These errors are not cumulative and are comparable with the interpreted target position errors achieved using DGPS.

2.1.3 Data Processing Description (provided by demonstrator)

a. Data Processing. The data will be processed in the following sequence (the software used at each step is noted in square brackets):

b. Data Acquisition.

(1) Up to two sensors of two-channel EM data will be recorded at 32 Hz in DGPS mode and at 5 cm in cotton odometer distance-mode [G-TEK's EMUDAS field data acquisition software].

(2) The GPS positions (at no less than 1 Hz) will be transformed in real-time into the required coordinate system [G-TEK's EMUDAS field data acquisition software].

(3) In cotton odometer mode, the precise vertices of the survey boundary and control lines are measured with the RTK-DGPS and entered into the TM-5 EMU EM. The operator will be responsible for activating the start and stop button for each line [G-TEK's EMUDAS].

(4) The GPS and EM data will be merged on the 32-Hz time-base in real-time. Drift corrections will then be applied [EMUDAS]. In distance-mode no merging is required.

(5) The data will automatically be assigned unique line-numbers during the data acquisition. The data will be indexed by these line-numbers during the line-based processing (i.e., up to the grid stage). Extraneous data will be either automatically or manually flagged as not required.

(6) The positions of the individual sensors will be calculated from the precisely measured sensor-GPS antenna offsets and the instantaneous track direction of the array. These individual sensor track positions will be referenced as sublines 1 to 2. In distance-mode this stage is automated [G-TEK's EMUDAS].

(7) All data will be transferred from the field device to the processing computer, and a Field Data Sheet will be completed by each crew leader (attachment A, DID OE-005-05.01).

c. Post-Processing by the Processing Geophysicist.

(1) The GPS track will be checked, edited, and smoothed, as required [Geosoft]. For cotton positioning, the distance recorded by the precise electronic odometer will be compared to the expected known length of each line [G-TEK's distance-based processing software].

(2) The EM data will then be automatically and manually scanned for the removal of invalid data [Geosoft].

(3) The raw data will be exported to Geosoft American Standard Code for Information Interchange (ASCII) XYZ format (with line reference headers and column labels) complying with the raw data submittal guidelines on the Standardized UXO Technology Demonstration Site-Submission for Scoring Web site. The data will then be written to compact disc (CD) for submission [Geosoft].

(4) The data will then be refiducialled to a distance-base of no greater than 0.05 meter to facilitate band-pass filtering to reduce effects with wavelengths determined to be inconsistent with the target anomalies (e.g., radio interference) [Geosoft-G-TEK's Geosoft executable (GXs)].

(5) Both channels of data will then be gridded to a square mesh no greater than 0.05 meter, using minimum curvature gridding with a maximum tension of 1 and using the Geosoft FLOAT grid format [Geosoft].

(6) Both channels of gridded data will then be loaded into the viewing and interpretation software for semiautomated interpretation. This process involves the automatic selection of positive and negative maximums and determining which amplitudes exceed the interpretation thresholds. These selections are then manually checked and amended. Parameters from the selected anomalies (from both channels) are then determined for use in an automated rule-based discrimination procedure. Use will be made of the ground-truth data from the calibration lane to fine-tune the discrimination settings. This will then provide the basis for the discrimination classification and prioritization in the submittal [G-TEK's MagSys].

(7) The information on the selected anomalies (processed data) will then be imported into a Microsoft (MS) Excel spreadsheet for formatting for presentation as a dig sheet based on the template attachment C, DID OE-005-05.01, and written to CD for submittal [G-TEK's EODReporter MS Excel macro].

(8) The dig sheet data (processed data) will also be reformatted to comply with the Processed Data Submittal guidelines on the Standardized UXO Technology Demonstration Site-Submission for Scoring Web site. The data will then be written to a CD for submission [MS Excel].

(9) The color contour, processed EM grid-image, with selected anomalies marked, will be presented based on the map template attachment D, DID OE-005-05.01, also on a CD [Geosoft].

d. Data processing during interrogation (Blind Test Grid). Anomaly parameters such as peak amplitude and width at half-amplitude in the north-south and east-west directions will be captured. These parameters will then be used in a rule based discrimination system for the discrimination classification and prioritization in the submittal [G-TEK's EODReporter].

2.1.4 Data Submission Format

Data were submitted for scoring in accordance with data submission protocols outlined in the Standardized UXO Technology Demonstration Site Handbook. These submitted data are not included in this report in order to protect ground truth information.

2.1.5 Demonstrator Quality Assurance (QA) and Quality Control (QC) (provided by demonstrator)

G-TEK will perform QC steps and tests using the DID OE-005-05.02 with the following QC test frequency:

Test Description	Power On	Day Start	Day Start and End	First Day	Repeat Last Two Grid Lines
Equipment warm-up	5 min				
Record sensor offsets		X			
Personnel test		X			
Vibration test		X			
Static and spike test			3 min/1 min/ 3 min		
Six-line test				X	
Repeat lines					X
Visit survey point			X		

Equipment/Electronics Warm-up for 5 Minutes: Allows for thermal stabilization of electronics.

Record Relative Sensor Position (Criteria: 1-cm Accuracy): Documents relative navigation and sensor offsets, detector separation, and detector heights above the ground surface.

Personnel Test (Criteria <10 EMU at 10 cm from Sensors): Ensures that survey personnel have removed all potential metallic interference sources from their bodies.

Shake Test (< Criteria 10 EMU): Identifies and repairs or replaces shorting cables and broken pin-outs on connectors. With the instrument held in a static position and collecting data, cables are shaken to test for shorts and broken pin-outs. Repaired or replaced cables are rigorously retested before use.

Static Background and Static Standard Response (Spike) Test (Criteria: 10 EMU): Quantifies instrument background readings and electronic drift, locates potential interference spikes, and determines impulse response and repeatability of the instrument to a standard item. Reviews in real time.

Six-Line Test (Criteria: Repeatability of Response Amplitude $\pm$20 percent, Positional Accuracy $\pm$20 cm): Documents latency, heading effects, repeatability of response amplitude, and positional accuracy. The test line will be well marked to facilitate data collection over the exact same line each time the test is performed. Background response over the test line is established in Lines 1 and 2. A standard test item, such as a steel trailer hitch ball, will be used for Lines 3 through 6.

Visit Survey Point (Criteria: $\pm$25 cm): Checks that GPS base location and transformations are correct.

Repeat Last Two Lines of Each Grid (Criteria: Repeatability of Response Amplitude $\pm$20 percent, Positional Accuracy $\pm$20 cm): Determines positional and geophysical data repeatability.

TM-5 EMU Calibration (Criteria: >250 EMU): By the use of a calibration device known as an "EMUlator" (developed by G-TEK for the purpose of establishing the integrity of the TM-5 EMU), the EMUlator is placed touching the rim of the sensor coil and data are recorded for a period of 60 seconds. The EMUlator delivers a controlled response to the excitation transmitted by the TM-5 EMU.

Sensor Elevation: The TM-5 EMU will be operated at a low but uniform elevation. To help the operator achieve this, a piece of non-conductive tape will be attached to the back of the coil such that it hangs 10 cm. The operator will then maintain the end of the tape just touching the ground (or where he judges the ground to be below the grass cover). Higher elevations due to vegetation will be noted.

Data Processing: A second geophysicist will check the data processing and interpretation. All intermediate processing stages of the data will be retained in meaningfully named columns within GEOSOFT for this purpose. All data will be backed up daily.

For QA measures, the data collected during the pre-survey QC checks will be processed, documented, and checked by the Data Processing Geophysicist to ensure that the entire system will provide the quality to achieve the desired outcome of detecting and correctly discriminating the UXO items down to their specified depth as determined by the site conditions. The RTK-DGPSs have a quoted accuracy of 2.0 cm + 0.1 mm/(km to the base station) Central Error Probability (CEP) in dynamic mode. In practice, however, assuming a consistent differential correction of 1 per second and a baseline less than 2 km, the worst case absolute accuracy will be $\pm$5.0 cm with a typical accuracy of $\pm$2.5 cm. Synchronization errors between the EM detector and the GPS will be reduced by calibration down to the resolution of the sampling rate of 0.03 second. In sloping terrain, there will be an additional error when the GPS antennae pole varies from the vertical.

In the forested areas, an electronic cotton odometer system will be used to track the sensors' positions along the line. This system has an inherent along-line accuracy of <1 percent and a resolution of 5 cm. However, when the start and end positions are known, this error is reduced to <0.2 percent of the distance between known points. In this case control lines at not greater than 25 m intervals are proposed, giving an accuracy of $\pm$ 5 cm.

Estimated Accuracy of the Navigation System: The primary navigation method will use accurately placed sighters along control lines. The operators must then keep at least two sighters in line with the center point of the sensor array. This navigation technique will be used with both the cotton and GPS position tracking systems. The advantage of this navigation system is its simplicity and applicability to difficult situations. Its accuracy depends on the accuracy of the pegged grid and the diligence of the operators. The anticipated typical across-line error is $\pm$10 cm. The effective swath width of the 2-sensor array will be 1.2 m. The nominal lane spacing of 1.0 m will allow for cross-line navigation variations.

QA of Positioning: The GEOSOFT Department of Defense (DoD) UXO QA system will be used to report on "Line Coverage Comparison." This report will allow the quantification of the data positioning on a line basis. Lines that fail will trigger "Re-Do" orders to Field Crew Leaders.

QA of Sensor Data Quality: The quality of each subline of data will be quantified as the largest distance with consecutive invalid sensor data. If a subline fails the criteria, a Re-Do order will be triggered. The magnetometer base station will be subjected to a similar quality quantification and recording process.

QA Based on a Two Traverse Resurvey: The sensor data and interpretation will be compared to the original, and the whole-system repeatability will be reported for QA.

QA of Data Processing: During data processing, the software will automatically correlate the dates and times of the various data streams. A second QC geophysicist will check the quality of the raw data, selected processing parameters, interpretation parameters, and final gridded data. QA of the interpretation will then be provided by checking each grid of data for missed anomalies. The QC geophysicist can then add but not delete more anomalies. The QC geophysicist will then repeat the discrimination process on 10 percent of the anomalies and compare the results. This process will ensure the quality of the final prioritized dig sheet result, which will allow the generation of a quantified ensured depth of detection versus caliber graph.

QA of Reacquisition and Validation: After anomaly validation entry of the finds into the dig sheet (based on the template Attachment C, DID OE-005-05.01), the dig sheet will be returned to the processing geophysicist, who will then check the description of the finds against the interpretation. Any discrepancies will be tracked on the dig sheet into columns, and the validation team may be asked to reinvestigate those items not signed off on by the geophysicist. The completed dig sheet will then provide a further QA product.

2.1.6 Additional Records

The following record(s) by this vendor can be accessed via the Internet as MicroSoft Word documents at www.uxotestsites.org. The counterparts to this report are the Blind Grid, Scoring Record No. 186, and the Open Field, Scoring Record No. 148.

2.2 YPG SITE INFORMATION

2.2.1 Location

YPG is located adjacent to the Colorado River in the Sonoran Desert. The UXO Standardized Test Site is located south of Pole Line Road and east of the Countermine Testing and Training Range. The Open Field range, Calibration Grid, Blind Grid, Mogul area, and Desert Extreme area comprise the 350 by 500-meter general test site area. The open field site is the largest of the test sites and measures approximately 200 by 350 meters. To the east of the open field range are the calibration and blind test grids that measure 30 by 40 meters and 40 by 40 meters, respectively. South of the Open Field is the 135- by 80-meter Mogul area consisting of a sequence of man-made depressions. The Desert Extreme area is located southeast of the open field site and has dimensions of 50 by 100 meters. The Desert Extreme area, covered with desert-type vegetation, is used to test the performance of different sensor platforms in a more severe desert conditions/environment.

2.2.2 Soil Type

Soil samples were collected at the YPG UXO Standardized Test Site by ERDC to characterize the shallow subsurface (< 3 m). Both surface grab samples and continuous soil borings were acquired. The soils were subjected to several laboratory analyses, including sieve/hydrometer, water content, magnetic susceptibility, dielectric permittivity, X-ray diffraction, and visual description.

There are two soil complexes present within the site, Riverbend-Carrizo and Cristobal-Gunsight. The Riverbend-Carrizo complex is comprised of mixed stream alluvium, whereas the Cristobal-Gunsight complex is derived from fan alluvium. The Cristobal-Gunsight complex covers the majority of the site. Most of the soil samples were classified as either a sandy loam or loamy sand, with most samples containing gravel-size particles. All samples had a measured water content less than 7 percent, except for two that contained 11-percent moisture. The majority of soil samples had water content between 1 to 2 percent. Samples containing more than 3 percent were generally deeper than 1 meter.

An X-ray diffraction analysis on four soil samples indicated a basic mineralogy of quartz, calcite, mica, feldspar, magnetite, and some clay. The presence of magnetite imparted a moderate magnetic susceptibility, with volume susceptibilities generally greater than 100 by 10-5 SI.

For more details concerning the soil properties at the YPG test site, go to www.uxotestsites.org on the web to view the entire soils description report.

2.2.3 Test Areas

A description of the test site areas at YPG is included in Table 2.

TABLE 2. TEST SITE AREAS

Area	Description
Calibration Grid	Contains the 15 standard ordnance items buried in six positions at various angles and depths to allow demonstrator equipment calibration.
Blind Grid	Contains 400 grid cells in a 0.16-hectare (0.39-acre) site. The center of each grid cell contains ordnance, clutter, or nothing.
Open Field	A 4-hectare (10-acre) site containing open areas, dips, ruts, and obstructions, including vegetation.
Mogul	A 2.64 acre area consisting of two areas (the rectangular or driving portion of the course and the triangular section with more difficult, non-drivable terrain). A series of craters (as deep as 0.91m) and trenches (as deep as 0.91m) encompass this section.

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (4 November 2003)

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total number of hours operated at each site are summarized in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	Number of Hours
Calibration Lanes	3.58
Mogul	7.38

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

A YPG weather station located approximately one mile west of the test site was used to record average temperature and precipitation on a half hour basis for each day of operation. The temperatures listed in Table 4 represent the average temperature during field operations from 0700 to 1700 hours while precipitation data represents a daily total amount of rainfall. Hourly weather logs used to generate this summary are provided in Appendix B.

TABLE 4. TEMPERATURE/PRECIPITATION DATA SUMMARY

Date, 2003	Average Temperature, °F	Total Daily Precipitation, in.
4 November	62.6	0.00

3.3.2 Field Conditions

The field was dry and the weather was warm throughout the G-TEK survey.

3.3.3 Soil Moisture

Three soil probes were placed at various locations within the site to capture soil moisture data: Blind Grid, Calibration, Desert Extreme, Open Field areas. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil depths (1 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in., and 36 to 48 in.) from each probe. Soil moisture logs are included in Appendix C.

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and break down. A two-person crew took 1 hours and 40 minutes to perform the initial setup and mobilization. There was 48 minutes of daily equipment preparation and no end of the day equipment break down.

3.4.2 Calibration

GTEK spent a total of 3 hours and 35 minutes in the calibration lanes, of which 1-hour and 44 minutes was spent collecting data. An additional 7 minutes was spent calibrating in the mogul area.

3.4.3 Downtime Occasions

Occasions of downtime are grouped into five categories: equipment/data checks or equipment maintenance, equipment failure and repair, weather, Demonstration Site issues, or breaks/lunch. All downtime is included for the purposes of calculating labor costs (section 5) except for downtime due to Demonstration Site issues. Demonstration Site issues, while noted in the Daily Log, are considered non-chargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are discussed in this section and billed to the total Site Survey area.

3.4.3.1 Equipment/data checks, maintenance. Equipment data checks and maintenance activities accounted for 40 minutes of site usage time. These activities included changing out batteries and routine data checks to ensure the data was being properly recorded/collected. G-TEK spent 51 minutes for breaks and lunches.

3.4.3.2 Equipment failure or repair. No time was needed to resolve equipment failures that occurred while surveying the Mogul.

3.4.3.3 Weather. No weather delays occurred during the survey.

3.4.4 Data Collection

G-TEK spent a total time of 7 hours and 23 minutes in the Mogul area, 5 hours and 4 minutes of which was spent collecting data.

3.4.5 Demobilization

The G-TEK survey crew went on to conduct a full demonstration of the site. Therefore, demobilization did not occur until 6 November 2003. On that day, it took the crew 1-hour and 17 minutes to break down and pack up their equipment.

3.5 PROCESSING TIME

G-TEK submitted the raw data from the demonstration activities on the last day of the demonstration, as required. The scoring submittal data was also provided within the required 30-day timeframe.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Mr. Peter Clark, Site Manager
Mr. Paul O'Donnell, Geophysicist
Mr. Bruce Symans, Crew Leader
Mr. Graham Browne, Field Technician
Mr. Terry Foot, Data Acquisition, Grid Setup

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

G-TEK surveyed the mogul area in a linear fashion and in a north to south and east to west direction.

3.8 SUMMARY OF DAILY LOGS

Daily logs capture all field activities during this demonstration and are located in Appendix D. Activities pertinent to this specific demonstration are indicated in highlighted text.

SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL ORDNANCE CATEGORIES

Figure 2 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive. Figure 3 shows both probabilities plotted against their respective background alarm rate. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

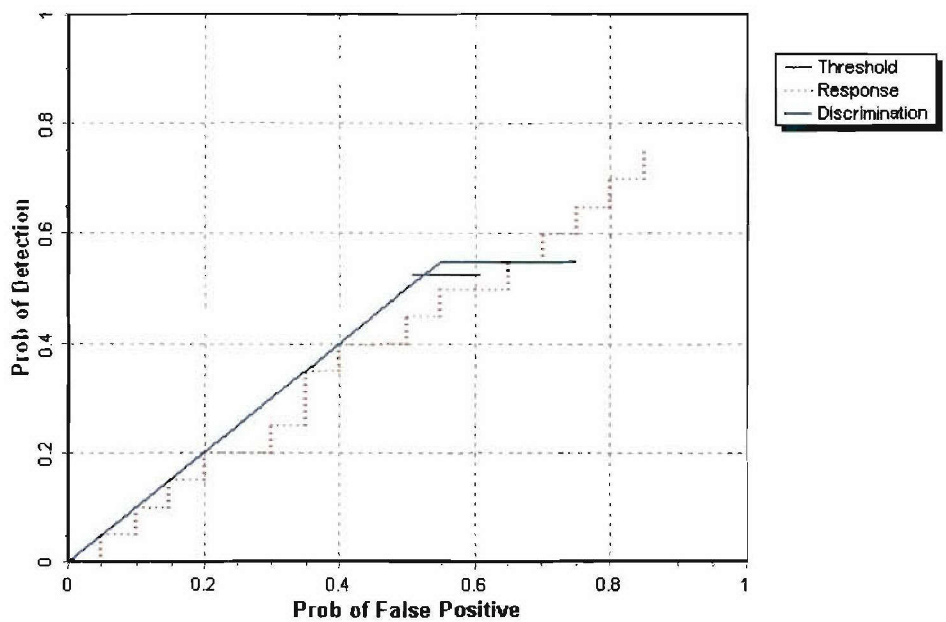


Figure 2. TM-5 EMU/sling mogul probability of detection for response and discrimination stages versus their respective probability of false positive over all ordnance categories combined.

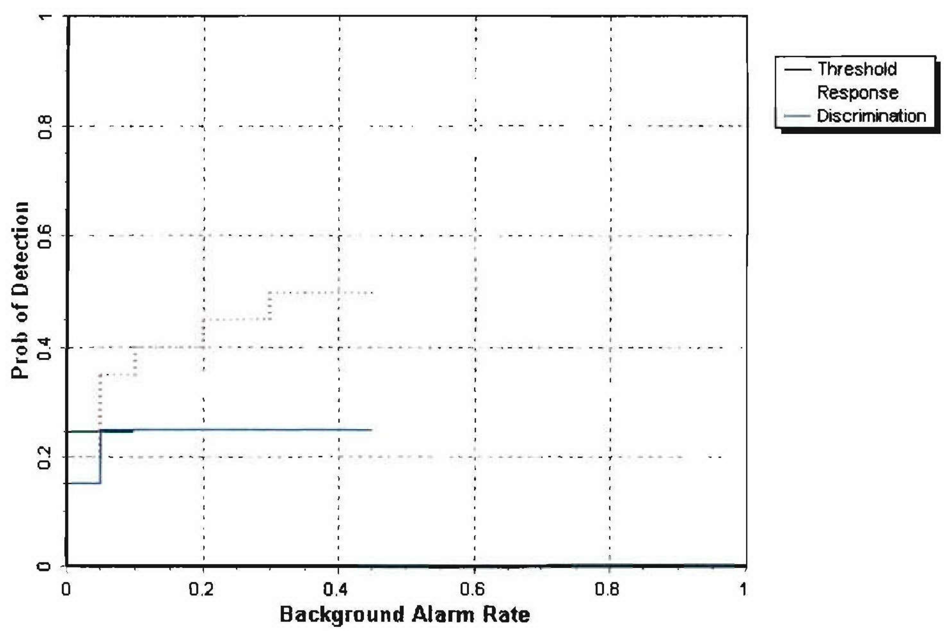


Figure 3. TM-5 EMU/sling mogul probability of detection for response and discrimination stages versus their respective background alarm rate over all ordnance categories combined.

4.2 ROC CURVES USING ORDNANCE LARGER THAN 20 MM

Figure 4 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive when only targets larger than 20 mm are scored. Figure 5 shows both probabilities plotted against their respective background alarm rate. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

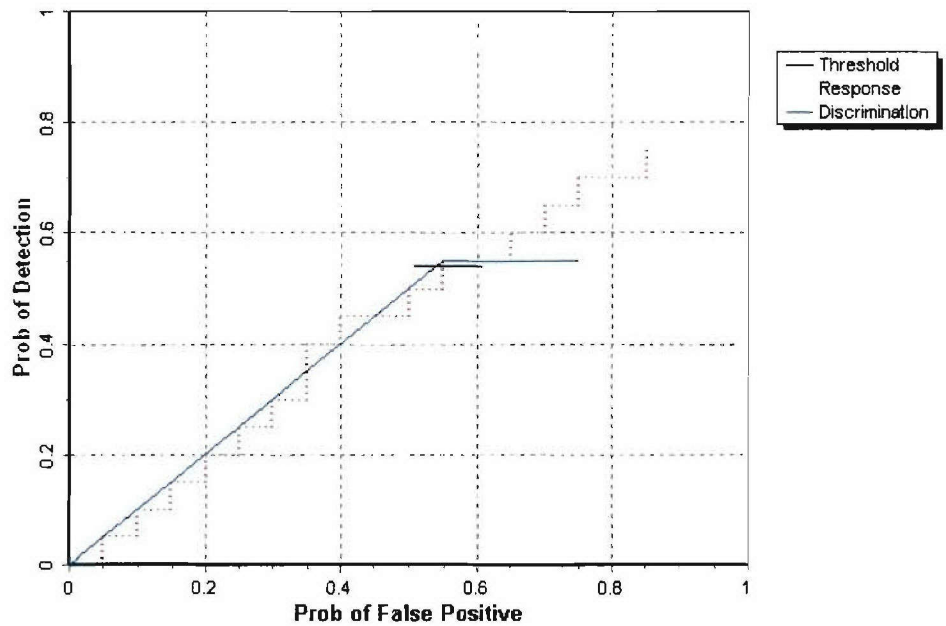


Figure 4. TM-5 EMU/sling mogul probability of detection for response and discrimination stages versus their respective probability of false positive for all ordnance larger than 20 mm.

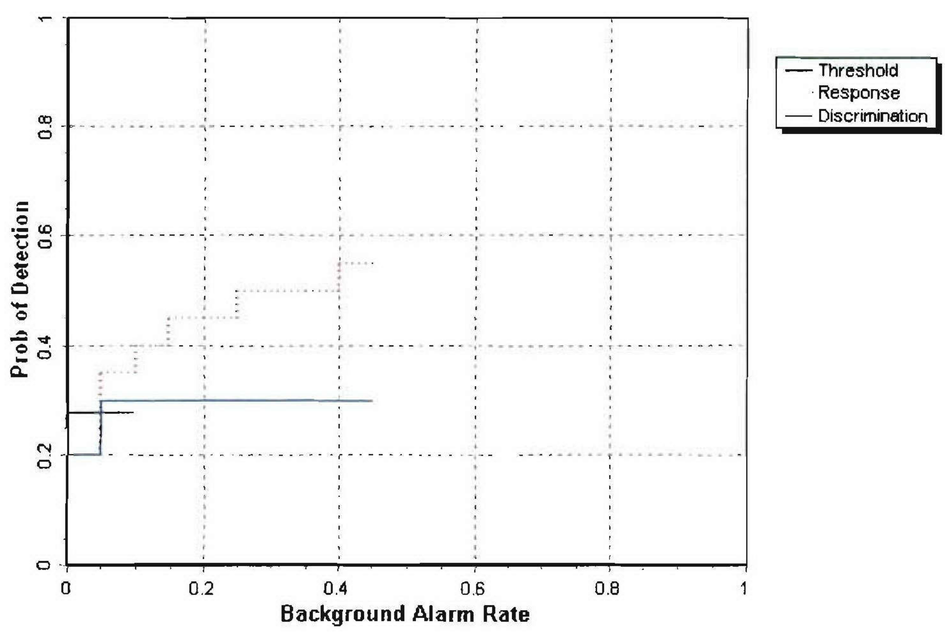


Figure 5. TM-5 EMU/sling mogul probability of detection for response and discrimination stages versus their respective background alarm rate for all ordnance larger than 20 mm.

4.3 PERFORMANCE SUMMARIES

Results for the Mogul Area test, broken out by size, depth and nonstandard ordnance are presented in Table 5 (for cost results, see section 5). Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range (see app A for size definitions). The results are relative to the number of ordnance items emplaced. Depth is measured from the geometric center of anomalies.

The RESPONSE STAGE results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the DISCRIMINATION STAGE are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90 percent confidence limit on probability of detection and P_{fp} was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results in Table 5 have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

TABLE 5. SUMMARY OF MOGUL RESULTS FOR TM-5 EMU/SLING

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.75	0.75	0.70	0.75	0.70	0.80	0.90	0.50	0.30
P_d Low 90% Conf	0.68	0.69	0.58	0.67	0.56	0.65	0.83	0.38	0.08
P_d Upper 90% Conf	0.79	0.83	0.78	0.82	0.78	0.93	0.94	0.62	0.60
P_{fp}	0.85	-	-	-	-	-	0.85	0.85	0.00
P_{fp} Low 90% Conf	0.81	-	-	-	-	-	0.81	0.74	0.00
P_{fp} Upper 90% Conf	0.88	-	-	-	-	-	0.89	0.91	0.68
BAR	0.10	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.55	0.50	0.55	0.65	0.45	0.35	0.65	0.35	0.15
P_d Low 90% Conf	0.46	0.44	0.43	0.54	0.32	0.20	0.57	0.23	0.01
P_d Upper 90% Conf	0.59	0.60	0.64	0.71	0.55	0.54	0.73	0.45	0.45
P_{fp}	0.55	-	-	-	-	-	0.50	0.75	0.00
P_{fp} Low 90% Conf	0.51	-	-	-	-	-	0.47	0.62	0.00
P_{fp} Upper 90% Conf	0.60	-	-	-	-	-	0.58	0.83	0.68
BAR	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 8.00
Recommended Discrimination Stage Threshold: 0.50

Note: The recommended discrimination stage threshold values are provided by the demonstrator.

4.4 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

Efficiency and rejection rates are calculated to quantify the discrimination ability at specific points of interest on the ROC curve: (1) at the point where no decrease in P_d is suffered (i.e., the efficiency is by definition equal to one) and (2) at the operator selected threshold. These values are reported in Table 6.

TABLE 6. EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	0.71	0.34	0.31
With No Loss of P_d	1.00	0.00	0.00

At the demonstrator's recommended setting, the ordnance items that were detected and correctly discriminated were further scored on whether their correct type could be identified (table 7). Correct type examples include "20-mm projectile, 105-mm HEAT Projectile, and 2.75-inch Rocket". A list of the standard type declaration required for each ordnance item was provided to demonstrators prior to testing. For example, the standard type for the three example items are 20mmP, 105H, and 2.75in, respectively.

TABLE 7. CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS UXO

Size	Percentage Correct
Small	22.5
Medium	0.0
Large	0.0
Overall	14.5

4.5 LOCATION ACCURACY

The mean location error and standard deviations appear in Table 8. These calculations are based on average missed depth for ordnance correctly identified in the discrimination stage. Depths are measured from the closest point of the ordnance to the surface. For the Blind Grid, only depth errors are calculated, since (X, Y) positions are known to be the centers of each grid square.

TABLE 8. MEAN LOCATION ERROR AND STANDARD DEVIATION (M)

	Mean	Standard Deviation
Northing	0.02	0.17
Easting	0.01	0.16
Depth	-0.25	0.29

SECTION 5. ON-SITE LABOR COSTS

A standardized estimate for labor costs associated with this effort was calculated as follows: the first person at the test site was designated "supervisor", the second person was designated "data analyst", and the third and following personnel were considered "field support". Standardized hourly labor rates were charged by title: supervisor at $95.00/hour, data analyst at $57.00/hour, and field support at $28.50/hour.

Government representatives monitored on-site activity. All on-site activities were grouped into one of ten categories: initial setup/mobilization, daily setup/stop, calibration, collecting data, downtime due to break/lunch, downtime due to equipment failure, downtime due to equipment/data checks or maintenance, downtime due to weather, downtime due to demonstration site issue, or demobilization. See Appendix D for the daily activity log. See section 3.4 for a summary of field activities.

The standardized cost estimate associated with the labor needed to perform the field activities is presented in Table 9. Note that calibration time includes time spent in the Calibration Lanes as well as field calibrations. "Site survey time" includes daily setup/stop time, collecting data, breaks/lunch, downtime due to equipment/data checks or maintenance, downtime due to failure, and downtime due to weather.

TABLE 9. ON-SITE LABOR COSTS

	No. People	Hourly Wage	Hours	Cost
		Initial Setup		
Supervisor	1	$95.00	1.66	$157.70
Data Analyst	1	57.00	1.66	94.62
Field Support	0	28.50	1.66	0.00
SubTotal				**$252.32**
		Calibration		
Supervisor	1	$95.00	3.70	$351.50
Data Analyst	1	57.00	3.70	210.90
Field Support	0	28.50	3.70	0.00
SubTotal				**$562.40**
		Site Survey		
Supervisor	1	$95.00	7.38	$701.10
Data Analyst	1	57.00	7.38	420.66
Field Support	0	28.50	7.38	0.00
SubTotal				**$1,121.76**

See notes at end of table.

TABLE 9 (CONT'D)

	No. People	Hourly Wage	Hours	Cost
Demobilization				
Supervisor	1	$95.00	1.28	$121.60
Data Analyst	1	57.00	1.28	72.96
Field Support	0	28.50	1.28	0.00
Subtotal				**$194.56**
Total				**$2,131.04**

Notes: Calibration time includes time spent in the Calibration Lanes as well as calibration before each data run.

Site Survey time includes daily setup/stop time, collecting data, breaks/lunch, downtime due to system maintenance, failure, and weather.

SECTION 6. COMPARISON OF RESULTS TO OPEN FIELD DEMONSTRATION

6.1 SUMMARY OF RESULTS FROM OPEN FIELD DEMONSTRATION

Table 10 shows the results from Open Field survey conducted prior to surveying the Moguls during the same site visit in October of 2003. For more details on the Open Field survey results reference section 2.1.6.

TABLE 10. SUMMARY OF OPEN FIELD RESULTS FOR THE TM-5 EMU (DUAL-SENSOR)/SLING

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.80	0.80	0.80	0.80	0.75	0.90	0.85	0.80	0.40
P_d Low 90% Conf	0.78	0.76	0.77	0.76	0.71	0.82	0.82	0.77	0.31
P_d Upper 90% Conf	0.82	0.82	0.85	0.83	0.81	0.92	0.87	0.85	0.53
P_{fp}	0.85	-	-	-	-	-	0.85	0.80	0.20
P_{fp} Low 90% Conf	0.82	-	-	-	-	-	0.83	0.79	0.05
P_{fp} Upper 90% Conf	0.84	-	-	-	-	-	0.86	0.85	0.45
BAR	0.10	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.50	0.50	0.45	0.45	0.45	0.60	0.45	0.60	0.40
P_d Low 90% Conf	0.46	0.48	0.40	0.42	0.41	0.52	0.39	0.56	0.31
P_d Upper 90% Conf	0.52	0.56	0.49	0.51	0.53	0.66	0.47	0.66	0.53
P_{fp}	0.50	-	-	-	-	-	0.40	0.70	0.20
P_{fp} Low 90% Conf	0.46	-	-	-	-	-	0.38	0.66	0.05
P_{fp} Upper 90% Conf	0.49	-	-	-	-	-	0.42	0.72	0.45
BAR	0.05	-	-	-	-	-	-	-	-

6.2 COMPARISON OF ROC CURVES USING ALL ORDNANCE CATEGORIES

Figure 6 shows P_d^{res} versus the respective P_{fp} over all ordnance categories. Figure 7 shows P_d^{disc} versus their respective P_{fp} over all ordnance categories. Figure 7 uses horizontal lines to illustrate the performance of the demonstrator at the recommended discrimination threshold levels, defining the subset of targets the demonstrator would recommend digging based on discrimination.

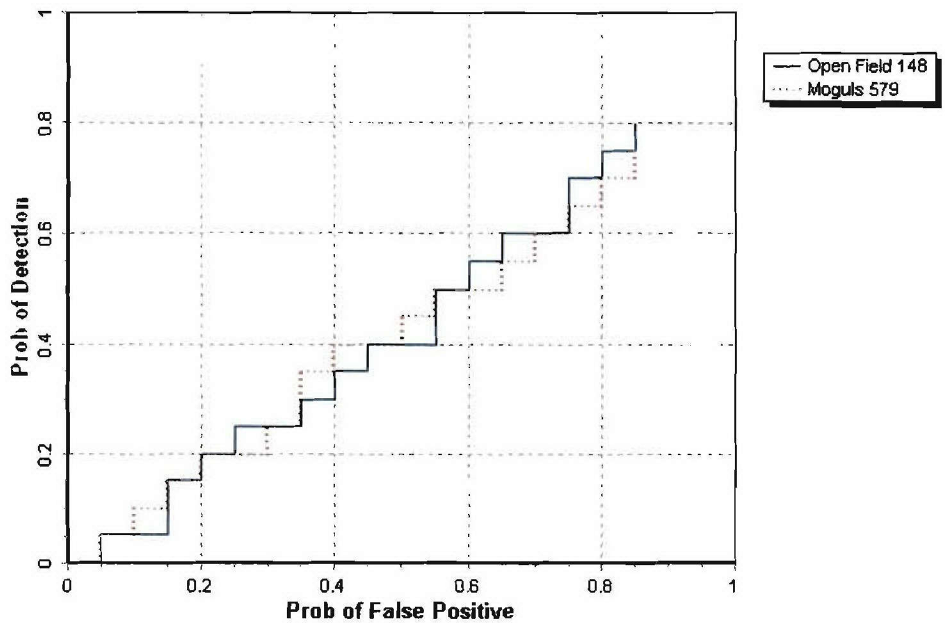


Figure 6. TM-5 EMU/sling P_d^{res} stages versus the respective P_{fp} over all ordnance categories combined.

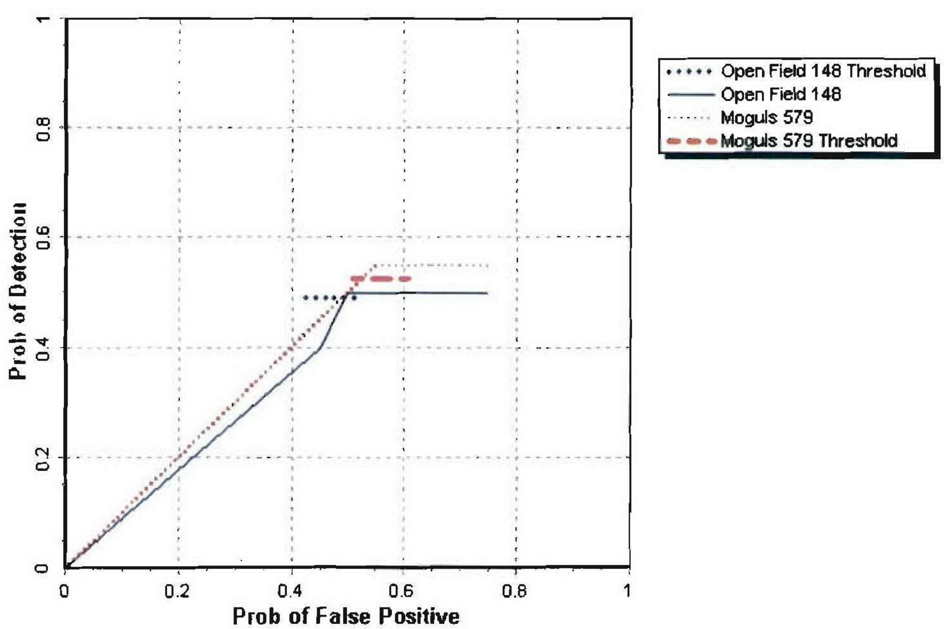


Figure 7. TM-5 EMU/sling P_d^{disc} versus the respective P_{fp} over all ordnance categories combined.

6.3 COMPARISON OF ROC CURVES USING ORDNANCE LARGER THAN 20 MM

Figure 8 shows the P_d^{res} versus the respective probability of P_{fp} over ordnance larger than 20 mm. Figure 9 shows P_d^{disc} versus the respective P_{fp} over ordnance larger than 20 mm. Figure 9 uses horizontal lines to illustrate the performance of the demonstrator at the recommended discrimination threshold levels, defining the subset of targets the demonstrator would recommend digging based on discrimination.

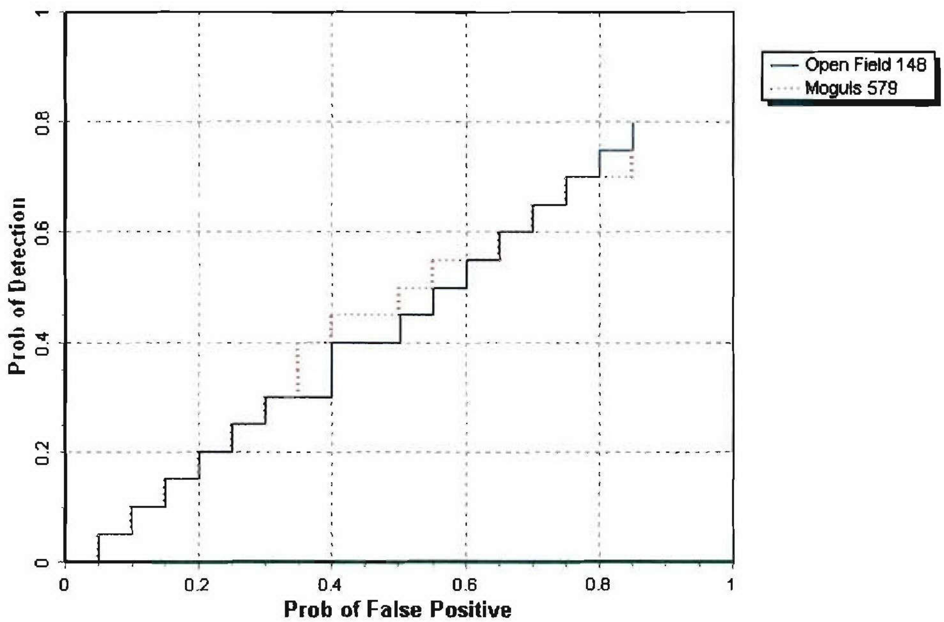


Figure 8. TM-5 EMU/sling P_d^{res} versus the respective P_{fp} for ordnance larger than 20 mm.

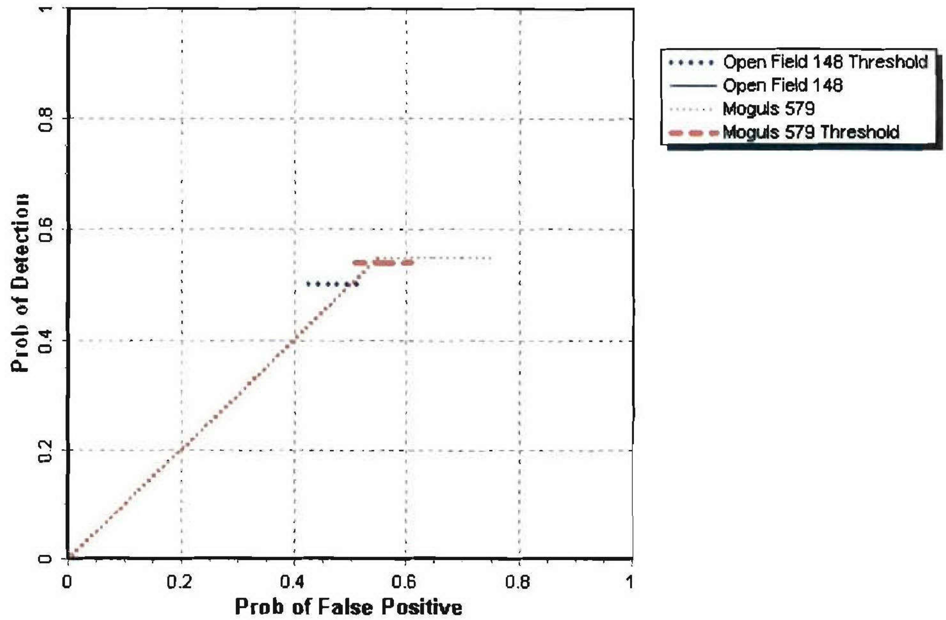


Figure 9. TM-5 EMU/sling P_d^{disc} versus the respective P_{fp} for ordnance larger than 20 mm.

6.4 STATISTICAL COMPARISONS

Statistical Chi-square significance tests were used to compare results between the Open Field and Mogul Area scenarios. The intent of the comparison is to determine if the feature introduced in each scenario has a degrading effect on the performance of the sensor system. However, any modifications in the UXO sensor system during the test, like changes in the processing or changes in the selection of the operating threshold, will also contribute to performance differences.

The Chi-square test for comparison between ratios was used at a significance level of 0.05 to compare Open Field to Mogul Area with regard to P_d^{res}, P_d^{disc}, P_{fp}^{res} and P_{fp}^{disc}, Efficiency and Rejection Rate. These results are presented in Table 11. A detailed explanation and example of the Chi-square application is located in Appendix A.

TABLE 11. CHI-SQUARE RESULTS – OPEN FIELD VERSUS MOGUL

Metric	Small	Medium	Large	Overall
P_d^{res}	Not Significant	Not Significant	Not Significant	Not Significant
P_d^{disc}	Significant	Not Significant	Not Significant	Not Significant
P_{fp}^{res}	Not Significant	Not Significant	Not Significant	Significant
P_{fp}^{disc}	-	-	-	Not Significant
Efficiency	-	-	-	Significant
Rejection rate	-	-	-	Significant

SECTION 7. APPENDIXES

APPENDIX A. TERMS AND DEFINITIONS

GENERAL DEFINITIONS

Anomaly: Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced ordnance item.

Detection: An anomaly location that is within R_{halo} of an emplaced ordnance item.

Emplaced Ordnance: An ordnance item buried by the government at a specified location in the test site.

Emplaced Clutter: A clutter item (i.e., non-ordnance item) buried by the government at a specified location in the test site.

R_{halo}: A pre-determined radius about the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} will be utilized. For the purpose of this program, a circular halo 0.5 meters in radius will be placed around the center of the object for all clutter and ordnance items less than 0.6 meters in length. When ordnance items are longer than 0.6 meters, the halo becomes an ellipse where the minor axis remains 1 meter and the major axis is equal to the length of the ordnance plus 1 meter.

Small Ordnance: Caliber of ordnance less than or equal to 40 mm (includes 20-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Ordnance: Caliber of ordnance greater than 40 mm and less than or equal to 81 mm (includes 57-mm projectile, 60-mm mortar, 2.75 in. Rocket, MK118 Rockeye, 81-mm mortar).

Large Ordnance: Caliber of ordnance greater than 81 mm (includes 105-mm HEAT, 105-mm projectile, 155-mm projectile, 500-pound bomb).

Shallow: Items buried less than 0.3 meter below ground surface.

Medium: Items buried greater than or equal to 0.3 meter and less than 1 meter below ground surface.

Deep: Items buried greater than or equal to 1 meter below ground surface.

Response Stage Noise Level: The level that represents the point below which anomalies are not considered detectable. Demonstrators are required to provide the recommended noise level for the Blind Grid test area.

Discrimination Stage Threshold: The demonstrator selected threshold level that they believe provides optimum performance of the system by retaining all detectable ordnance and rejecting the maximum amount of clutter. This level defines the subset of anomalies the demonstrator would recommend digging based on discrimination.

Binomially Distributed Random Variable: A random variable of the type which has only two possible outcomes, say success and failure, is repeated for n independent trials with the probability p of success and the probability 1-p of failure being the same for each trial. The number of successes x observed in the n trials is an estimate of p and is considered to be a binomially distributed random variable.

RESPONSE AND DISCRIMINATION STAGE DATA

The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}) and those that do not correspond to any known item, termed background alarms.

The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the RESPONSE STAGE, the demonstrator provides the scoring committee with the location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the RESPONSE STAGE anomaly list, the DISCRIMINATION STAGE list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide "optimum" system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Note: The two lists provided by the demonstrator contain identical numbers of potential target locations. They differ only in the priority ranking of the declarations.

RESPONSE STAGE DEFINITIONS

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (No. of response-stage detections)/(No. of emplaced ordnance in the test site).

Response Stage False Positive (fp^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (No. of response-stage false positives)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Response Stage Probability of Background Alarm (P_{ba}^{res}): Blind Grid only: P_{ba}^{res} = (No. of response-stage background alarms)/(No. of empty grid locations).

Response Stage Background Alarm Rate (BAR^{res}): Open Field only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{fp}^{res}, P_{ba}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. These quantities can therefore be written as $P_d^{res}(t^{res})$, $P_{fp}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to response-stage data that discriminates ordnance from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to ordnance, as well as those that the demonstrator has high confidence correspond to nonordnance or background returns. The former should be ranked with highest priority and the latter with lowest.

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (No. of discrimination-stage detections)/(No. of emplaced ordnance in the test site).

Discrimination Stage False Positive (fp^{disc}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (No. of discrimination stage false positives)/(No. of emplaced clutter items).

Discrimination Stage Background Alarm (ba^{disc}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

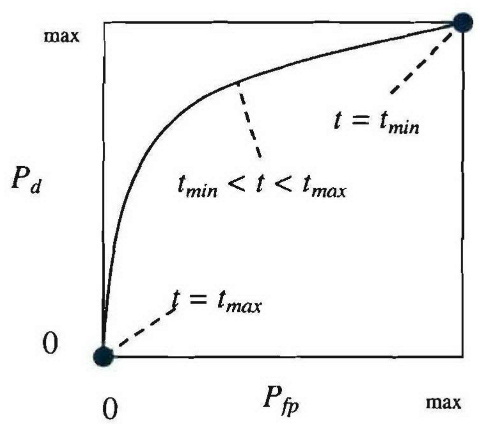
Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (No. of discrimination-stage background alarms)/(No. of empty grid locations).

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (No. of discrimination-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, P_{ba}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. These quantities can therefore be written as $P_d^{disc}(t^{disc})$, $P_{fp}^{disc}(t^{disc})$, $P_{ba}^{disc}(t^{disc})$, and $BAR^{disc}(t^{disc})$.

RECEIVER-OPERATING CHARACERISTIC (ROC) CURVES

ROC curves at both the response and discrimination stages can be constructed based on the above definitions. The ROC curves plot the relationship between P_d versus P_{fp} and P_d versus BAR or P_{ba} as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.[1] Figure A-1 shows how P_d versus P_{fp} and P_d versus BAR are combined into ROC curves. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.



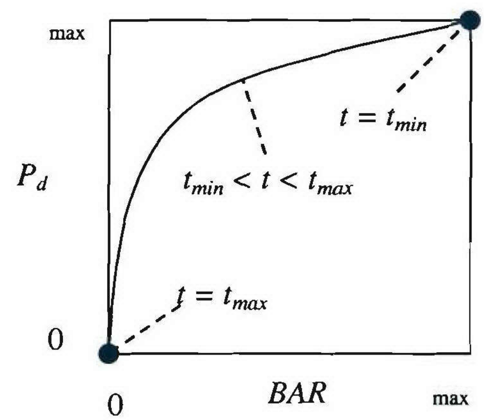


Figure A-1. ROC curves for open field testing. Each curve applies to both the response and discrimination stages.

[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a pre-determined and fixed number of detection opportunities (some of the opportunities are located over ordnance and others are located over clutter or blank spots). In an open field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the Blind Grid test sites are true ROC curves.

METRICS TO CHARACTERIZE THE DISCRIMINATION STAGE

The demonstrator is also scored on efficiency and rejection ratio, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from nonordnance items. The efficiency measures the amount of detected ordnance retained by the discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$; Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage tmin) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage tmin). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

Background Alarm Rejection Rate (R_{ba}):

Blind Grid: $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$.
Open Field: $R_{ba} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})])$.

Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

CHI-SQUARE COMPARISON EXPLANATION:

The Chi-square test for differences in probabilities (or 2 x 2 contingency table) is used to analyze two samples drawn from two different populations to see if both populations have the same or different proportions of elements in a certain category. More specifically, two random samples are drawn, one from each population, to test the null hypothesis that the probability of event A (some specified event) is the same for both populations (ref 3).

A 2 x 2 contingency table is used in the Standardized UXO Technology Demonstration Site Program to determine if there is reason to believe that the proportion of ordnance correctly detected/discriminated by demonstrator X's system is significantly degraded by the more challenging terrain feature introduced. The test statistic of the 2 x 2 contingency table is the

Chi-square distribution with one degree of freedom. Since an association between the more challenging terrain feature and relatively degraded performance is sought, a one-sided test is performed. A significance level of 0.05 is chosen which sets a critical decision limit of 2.71 from the Chi-square distribution with one degree of freedom. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, the two proportions tested will be considered significantly different. If the test statistic calculated from the data is less than this value, the two proportions tested will be considered not significantly different.

An exception must be applied when either a 0 or 100 percent success rate occurs in the sample data. The Chi-square test cannot be used in these instances. Instead, Fischer's test is used and the critical decision limit for one-sided tests is the chosen significance level, which in this case is 0.05. With Fischer's test, if the test statistic is less than the critical value, the proportions are considered to be significantly different.

Standardized UXO Technology Demonstration Site examples, where blind grid results are compared to those from the open field and open field results are compared to those from one of the scenarios, follow. It should be noted that a significant result does not prove a cause and effect relationship exists between the two populations of interest; however, it does serve as a tool to indicate that one data set has experienced a degradation in system performance at a large enough level than can be accounted for merely by chance or random variation. Note also that a result that is not significant indicates that there is not enough evidence to declare that anything more than chance or random variation within the same population is at work between the two data sets being compared.

Demonstrator X achieves the following overall results after surveying each of the three progressively more difficult areas using the same system (results indicate the number of ordnance detected divided by the number of ordnance emplaced):

	Blind Grid	Open Field	Moguls
P_d^{res}	100/100 = 1.0	8/10 = .80	20/33 = .61
P_d^{disc}	80/100 = 0.80	6/10 = .60	8/33 = .24

P_d^{res}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the response stage, all 100 ordnance out of 100 emplaced ordnance items were detected in the blind grid while 8 ordnance out of 10 emplaced were detected in the open field. Fischer's test must be used since a 100 percent success rate occurs in the data. Fischer's test uses the four input values to calculate a test statistic of 0.0075 that is compared against the critical value of 0.05. Since the test statistic is less than the critical value, the smaller response stage detection rate (0.80) is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the detection ability of demonstrator X's system seems to have been degraded in the open field relative to results from the blind grid using the same system.

P_d^{disc}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the discrimination stage, 80 out of 100 emplaced ordnance items were correctly discriminated as ordnance in blind grid testing while 6 ordnance out of 10 emplaced were correctly discriminated as such in open field-testing. Those four values are used to calculate a test statistic of 1.12. Since the test statistic is less than the critical value of 2.71, the two discrimination stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{res}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the response stage, 8 out of 10 and 20 out of 33 are used to calculate a test statistic of 0.56. Since the test statistic is less than the critical value of 2.71, the two response stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{disc}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the discrimination stage, 6 out of 10 and 8 out of 33 are used to calculate a test statistic of 2.98. Since the test statistic is greater than the critical value of 2.71, the smaller discrimination stage detection rate is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the ability of demonstrator X to correctly discriminate seems to have been degraded by the mogul terrain relative to results from the flat open field using the same system.

APPENDIX B. DAILY WEATHER LOGS

TABLE B-1. WEATHER LOG

Date	Time, HH:MM	Temperature, °F	RH, %	Total Precipitation, in.
10/28/2003	01:00	65.46	14	0.00
10/28/2003	02:00	65.64	15	0.00
10/28/2003	03:00	62.76	16	0.00
10/28/2003	04:00	61.83	17	0.00
10/28/2003	05:00	62.01	18	0.00
10/28/2003	06:00	59.86	19	0.00
10/28/2003	07:00	60.35	20	0.00
10/28/2003	08:00	63.12	20	0.00
10/28/2003	09:00	71.33	15	0.00
10/28/2003	10:00	78.94	13	0.00
10/28/2003	11:00	82.76	12	0.00
10/28/2003	12:00	86.43	11	0.00
10/28/2003	13:00	89.37	10	0.00
10/28/2003	14:00	91.02	10	0.00
10/28/2003	15:00	93.04	9	0.00
10/28/2003	16:00	93.78	9	0.00
10/28/2003	17:00	92.84	10	0.00
10/28/2003	18:00	88.97	12	0.00
10/28/2003	19:00	84.58	13	0.00
10/28/2003	20:00	82.54	13	0.00
10/28/2003	21:00	77.09	14	0.00
10/28/2003	22:00	75.78	15	0.00
10/28/2003	23:00	71.92	24	0.00
10/28/2003	24:00	69.57	23	0.00
10/29/2003	01:00	70.23	27	0.00
10/29/2003	02:00	69.30	29	0.00
10/29/2003	03:00	68.20	34	0.00
10/29/2003	04:00	67.23	36	0.00
10/29/2003	05:00	67.01	38	0.00
10/29/2003	06:00	65.46	42	0.00
10/29/2003	07:00	68.27	47	0.00
10/29/2003	08:00	67.60	55	0.00
10/29/2003	09:00	70.36	46	0.00
10/29/2003	10:00	72.52	39	0.00
10/29/2003	11:00	76.87	36	0.00
10/29/2003	12:00	82.27	39	0.00

TABLE B-1 (CONT'D)

Date	Time, HH:MM	Temperature, °F	RH, %	Total Precipitation, in.
10/29/2003	13:00	84.42	33	0.00
10/29/2003	14:00	87.82	26	0.00
10/29/2003	15:00	88.50	24	0.00
10/29/2003	16:00	88.83	21	0.00
10/29/2003	17:00	88.38	26	0.00
10/29/2003	18:00	86.09	29	0.00
10/29/2003	19:00	82.92	34	0.00
10/29/2003	20:00	79.86	37	0.00
10/29/2003	21:00	77.20	41	0.00
10/29/2003	22:00	74.68	48	0.00
10/29/2003	23:00	72.09	50	0.00
10/29/2003	24:00	69.93	53	0.00
10/30/2003	01:00	68.38	63	0.00
10/30/2003	02:00	68.04	69	0.00
10/30/2003	03:00	66.49	72	0.00
10/30/2003	04:00	64.63	72	0.00
10/30/2003	05:00	63.55	74	0.00
10/30/2003	06:00	64.63	77	0.00
10/30/2003	07:00	64.74	78	0.00
10/30/2003	08:00	64.08	79	0.00
10/30/2003	09:00	70.36	55	0.00
10/30/2003	10:00	72.36	37	0.00
10/30/2003	11:00	75.02	35	0.00
10/30/2003	12:00	76.33	32	0.00
10/30/2003	13:00	77.61	31	0.00
10/30/2003	14:00	78.33	29	0.00
10/30/2003	15:00	79.23	28	0.00
10/30/2003	16:00	78.40	30	0.00
10/30/2003	17:00	77.59	30	0.00
10/30/2003	18:00	75.43	33	0.00
10/30/2003	19:00	73.13	36	0.00
10/30/2003	20:00	71.42	38	0.00
10/30/2003	21:00	68.74	43	0.00
10/30/2003	22:00	65.79	47	0.00
10/30/2003	23:00	65.30	47	0.00
10/30/2003	24:00	63.59	49	0.00

TABLE B-1 (CONT'D)

Date	Time, HH:MM	Temperature, °F	RH, %	Total Precipitation, in.
10/31/2003	01:00	62.06	51	0.00
10/31/2003	02:00	60.78	53	0.00
10/31/2003	03:00	60.62	53	0.00
10/31/2003	04:00	60.85	53	0.00
10/31/2003	05:00	59.92	54	0.00
10/31/2003	06:00	59.92	54	0.00
10/31/2003	07:00	58.26	56	0.00
10/31/2003	08:00	57.60	57	0.00
10/31/2003	09:00	63.91	47	0.00
10/31/2003	10:00	65.59	42	0.00
10/31/2003	11:00	67.21	40	0.00
10/31/2003	12:00	68.72	38	0.00
10/31/2003	13:00	71.01	35	0.00
10/31/2003	14:00	72.16	34	0.00
10/31/2003	15:00	73.31	33	0.00
10/31/2003	16:00	73.00	32	0.00
10/31/2003	17:00	71.80	33	0.00
10/31/2003	18:00	69.76	34	0.00
10/31/2003	19:00	67.69	35	0.00
10/31/2003	20:00	65.88	36	0.00
10/31/2003	21:00	64.65	38	0.00
10/31/2003	22:00	64.20	38	0.00
10/31/2003	23:00	64.45	37	0.00
10/31/2003	24:00	64.53	37	0.00
11/01/2003	01:00	63.45	39	0.00
11/01/2003	02:00	62.69	41	0.00
11/01/2003	03:00	62.22	43	0.00
11/01/2003	04:00	62.06	42	0.00
11/01/2003	05:00	60.67	43	0.00
11/01/2003	06:00	61.30	42	0.00
11/01/2003	07:00	60.64	43	0.00
11/01/2003	08:00	60.49	43	0.00
11/01/2003	09:00	63.10	39	0.00
11/01/2003	10:00	66.65	33	0.00
11/01/2003	11:00	69.15	31	0.00
11/01/2003	12:00	69.91	31	0.00
11/01/2003	13:00	70.99	31	0.00
11/01/2003	14:00	73.85	30	0.00

TABLE B-1 (CONT'D)

Date	Time, HH:MM	Temperature, °F	RH, %	Total Precipitation, in.
11/01/2003	15:00	74.55	28	0.00
11/01/2003	16:00	74.70	27	0.00
11/01/2003	17:00	74.12	29	0.00
11/01/2003	18:00	72.10	33	0.00
11/01/2003	19:00	69.60	35	0.00
11/01/2003	20:00	66.65	39	0.00
11/01/2003	21:00	64.90	42	0.00
11/01/2003	22:00	63.64	43	0.00
11/01/2003	23:00	63.10	44	0.00
11/01/2003	24:00	60.35	46	0.00
11/02/2003	01:00	59.90	47	0.00
11/02/2003	02:00	59.92	46	0.00
11/02/2003	03:00	59.68	46	0.00
11/02/2003	04:00	57.36	49	0.00
11/02/2003	05:00	56.98	49	0.00
11/02/2003	06:00	54.25	49	0.00
11/02/2003	07:00	52.99	52	0.00
11/02/2003	08:00	57.04	47	0.00
11/02/2003	09:00	62.78	44	0.00
11/02/2003	10:00	65.44	40	0.00
11/02/2003	11:00	68.85	36	0.00
11/02/2003	12:00	70.00	34	0.00
11/02/2003	13:00	71.44	31	0.00
11/02/2003	14:00	70.09	33	0.00
11/02/2003	15:00	68.68	34	0.00
11/02/2003	16:00	67.78	34	0.00
11/02/2003	17:00	67.75	33	0.00
11/02/2003	18:00	66.63	33	0.00
11/02/2003	19:00	65.21	33	0.00
11/02/2003	20:00	64.58	33	0.00
11/02/2003	21:00	63.39	36	0.00
11/02/2003	22:00	61.77	42	0.00
11/02/2003	23:00	60.31	45	0.00
11/02/2003	24:00	58.93	48	0.00
11/03/2003	01:00	58.57	44	0.00
11/03/2003	02:00	57.04	45	0.00
11/03/2003	03:00	56.30	45	0.00
11/03/2003	04:00	53.82	49	0.00
11/03/2003	05:00	54.32	48	0.00

TABLE B-1 (CONT'D)

Date	Time, HH:MM	Temperature, °F	RH, %	Total Precipitation, in.
11/03/2003	06:00	53.62	48	0.00
11/03/2003	07:00	53.69	47	0.00
11/03/2003	08:00	55.26	44	0.00
11/03/2003	09:00	58.17	41	0.00
11/03/2003	10:00	61.61	35	0.00
11/03/2003	11:00	64.69	32	0.00
11/03/2003	12:00	65.41	32	0.00
11/03/2003	13:00	66.27	32	0.00
11/03/2003	14:00	67.33	29	0.00
11/03/2003	15:00	68.25	28	0.00
11/03/2003	16:00	68.13	27	0.00
11/03/2003	17:00	67.46	27	0.00
11/03/2003	18:00	65.91	30	0.00
11/03/2003	19:00	63.72	33	0.00
11/03/2003	20:00	62.13	34	0.00
11/03/2003	21:00	60.15	37	0.00
11/03/2003	22:00	59.52	39	0.00
11/03/2003	23:00	56.79	44	0.00
11/03/2003	24:00	56.91	47	0.00
11/04/2003	01:00	54.28	51	0.00
11/04/2003	02:00	55.49	53	0.00
11/04/2003	03:00	52.99	56	0.00
11/04/2003	04:00	50.79	62	0.00
11/04/2003	05:00	52.66	63	0.00
11/04/2003	06:00	51.39	66	0.00
11/04/2003	07:00	47.80	67	0.00
11/04/2003	08:00	51.37	62	0.00
11/04/2003	09:00	57.65	55	0.00
11/04/2003	10:00	60.62	48	0.00
11/04/2003	11:00	63.50	38	0.00
11/04/2003	12:00	65.64	33	0.00
11/04/2003	13:00	66.88	31	0.00
11/04/2003	14:00	67.57	29	0.00
11/04/2003	15:00	69.42	26	0.00
11/04/2003	16:00	69.31	27	0.00
11/04/2003	17:00	68.83	27	0.00
11/04/2003	18:00	66.58	33	0.00
11/04/2003	19:00	64.29	35	0.00
11/04/2003	20:00	62.31	37	0.00

TABLE B-1 (CONT'D)

Date	Time, HH:MM	Temperature, °F	RH, %	Total Precipitation, in.
11/04/2003	21:00	59.70	41	0.00
11/04/2003	22:00	57.22	42	0.00
11/04/2003	23:00	53.87	43	0.00
11/04/2003	24:00	52.23	45	0.00
11/05/2003	01:00	50.90	47	0.00
11/05/2003	02:00	49.35	47	0.00
11/05/2003	03:00	48.38	51	0.00
11/05/2003	04:00	46.58	48	0.00
11/05/2003	05:00	45.10	48	0.00
11/05/2003	06:00	44.98	51	0.00
11/05/2003	07:00	46.62	52	0.00
11/05/2003	08:00	49.50	51	0.00
11/05/2003	09:00	57.15	42	0.00
11/05/2003	10:00	64.33	31	0.00
11/05/2003	11:00	66.29	29	0.00
11/05/2003	12:00	69.53	26	0.00
11/05/2003	13:00	70.09	25	0.00
11/05/2003	14:00	71.82	23	0.00
11/05/2003	15:00	73.11	21	0.00
11/05/2003	16:00	73.65	20	0.00
11/05/2003	17:00	72.68	20	0.00
11/05/2003	18:00	70.14	21	0.00
11/05/2003	19:00	67.89	22	0.00
11/05/2003	20:00	64.02	25	0.00
11/05/2003	21:00	63.01	26	0.00
11/05/2003	22:00	60.13	29	0.00
11/05/2003	23:00	57.81	30	0.00
11/05/2003	24:00	53.87	30	0.00
11/06/2003	01:00	52.18	32	0.00
11/06/2003	02:00	52.03	34	0.00
11/06/2003	03:00	50.58	35	0.00
11/06/2003	04:00	48.34	37	0.00
11/06/2003	05:00	48.85	39	0.00
11/06/2003	06:00	47.93	40	0.00
11/06/2003	07:00	47.73	44	0.00
11/06/2003	08:00	53.42	38	0.00
11/06/2003	09:00	61.84	29	0.00
11/06/2003	10:00	64.06	27	0.00
11/06/2003	11:00	69.28	23	0.00

TABLE B-1 (CONT'D)

Date	Time, HH:MM	Temperature, °F	RH, %	Total Precipitation, in.
11/06/2003	12:00	70.75	22	0.00
11/06/2003	13:00	72.32	21	0.00
11/06/2003	14:00	74.43	19	0.00
11/06/2003	15:00	74.03	19	0.00
11/06/2003	16:00	75.04	18	0.00
11/06/2003	17:00	74.39	18	0.00
11/06/2003	18:00	71.56	20	0.00
11/06/2003	19:00	68.04	22	0.00
11/06/2003	20:00	64.33	24	0.00
11/06/2003	21:00	62.60	25	0.00
11/06/2003	22:00	60.35	27	0.00
11/06/2003	23:00	61.30	26	0.00
11/06/2003	24:00	56.84	29	0.00

TABLE C-1. DAILY SOIL MOISTURE LOG

Date	Time	Calibration Area, %					Time	Mogul Area, %					Time	Extreme Area, %				
		0 - 6 in.	6 -12 in.	12-24 in.	24-36 in.	36-48 in.		0 - 6 in.	6 -12 in.	12-24 in.	24-36 in.	36-48 in.		0 - 6 in.	6 -12 in.	12-24 in.	24-36 in.	36-48 in.
10/28/2003	955	1.8	2.3	3.7	3.6	4.0	1004	1.7	2.0	3.5	4.0	4.1	1013	1.6	2.1	3.4	4.0	4.2
	1405	1.8	2.2	3.7	3.6	4.0	1413	1.7	2.0	3.5	4.0	4.1	1420	1.6	2.1	3.4	4.0	4.1
10/29/2003	705	1.8	2.3	3.7	3.6	4.0	713	1.7	2.0	3.6	3.9	4.0	719	1.6	2.1	3.4	4.0	4.1
	1300	1.8	2.3	3.7	3.6	4.0	1310	1.7	2.0	3.6	3.9	4.0	1318	1.6	2.1	3.4	4.0	4.1
10/30/2003	730	1.8	2.3	3.7	3.6	4.0	738	1.7	2.0	3.5	3.9	4.0	745	1.6	2.1	3.4	4.0	4.2
	1502	1.8	2.3	3.7	3.6	4.0	1513	1.8	2.0	3.6	4.0	4.1	1518	1.6	2.1	3.4	4.0	4.1
10/31/2003	651	1.8	2.3	3.7	3.6	4.0	703	1.6	2.0	3.5	3.9	4.0	712	1.6	2.1	3.4	4.0	4.2
	1422	1.8	2.3	3.7	3.6	4.0	1434	1.7	2.0	3.6	3.9	4.1	1444	1.6	2.1	3.4	3.9	4.1
11/3/2003	650	1.8	2.3	3.7	3.6	4.0	659	1.7	2.0	3.6	3.9	4.0	707	1.6	2.1	3.4	3.9	4.1
	1400	1.8	2.3	3.7	3.6	4.0	1408	1.7	2.0	3.6	3.9	4.0	1419	1.6	2.1	3.4	3.9	4.1
11/4/2003	635	1.8	2.3	3.7	3.6	4.0	643	1.7	2.0	3.6	3.9	4.1	650	1.6	2.1	3.4	3.9	4.1
	1340	1.8	2.3	3.7	3.6	4.0	1348	1.7	2.0	3.5	3.9	4.1	1357	1.6	2.1	3.4	3.9	4.1
11/5/2003	645	1.8	2.3	3.7	3.6	4.0	653	1.7	2.0	3.5	3.9	4.0	701	1.6	2.1	3.4	3.9	4.1
	1420	1.8	2.3	3.7	3.6	4.0	1429	1.7	2.0	3.6	3.9	4.0	1438	1.6	2.1	3.4	3.9	4.1
11/6/2003	640	1.8	2.3	3.7	3.6	4.0	648	1.7	2.0	3.5	3.9	4.0	657	1.6	2.0	3.4	3.9	4.1
	1400	1.8	2.3	3.7	3.6	4.0	1408	1.7	2.0	3.5	3.9	4.0	1415	1.6	2.0	3.4	3.9	4.1

APPENDIX D. DAILY ACTIVITY LOGS

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
10/28/2003	2	INITIAL SETUP	0930	1110	100	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
10/28/2003	1	BLIND TEST GRID	1110	1125	15	COLLECTING DATA	SIX-LANE CALIBRATION WITH BOLTS	GPS	LINER	HOT	DRY
10/28/2003	1	BLIND TEST GRID	1125	1207	42	COLLECTING DATA	RUNNING BTG NORTH/ SOUTH	GPS	LINER	HOT	DRY
10/28/2003	2	BLIND TEST GRID	1207	1220	13	DOWNTIME DUE TO EQUIPMENT MAINT/CHECK	CHECKING/DOWNLOADING DATA	NA	NA	HOT	DRY
10/28/2003	1	CALIBRATION LANE	1220	1240	20	COLLECTING DATA	RUNNING CALIBRATION LANE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/28/2003	2	CALIBRATION LANE	1240	1247	7	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	COULD NOT GET A FIX ON GPS	NA	NA	HOT	DRY
10/28/2003	1	CALIBRATION LANE	1247	1319	32	COLLECTING DATA	RUNNING CALIBRATION LANE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/28/2003	2	CALIBRATION LANE	1319	1330	11	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	CHECKING/DOWNLOADING DATA	NA	NA	HOT	DRY
10/28/2003	2	CALIBRATION LANE	1330	1335	5	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	REPLACED BATTERY	NA	NA	HOT	DRY
10/28/2003	2	OPEN RANGE	1335	1415	40	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
10/28/2003	1	OPEN RANGE	1415	1545	90	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/28/2003	1	OPEN RANGE	1545	1601	16	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
10/28/2003	1	OPEN RANGE	1601	1646	45	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/28/2003	2	OPEN RANGE	1646	1700	14	SETUP/ MOBILIZATION	EQUIPMENT BREAKDOWN EOD	NA	NA	HOT	DRY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
10/29/2003	2	OPEN RANGE	0655	0856	121	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
10/29/2003	1	OPEN RANGE	0856	0900	4	COLLECTING DATA	SIX-LANE CALIBRATION WITH BOLTS	GPS	LINER	HOT	DRY
10/29/2003	2	OPEN RANGE	0900	0910	10	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
10/29/2003	1	OPEN RANGE	0910	1130	140	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/29/2003	1	OPEN RANGE	1130	1135	5	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	REPLACED BATTERY	NA	NA	HOT	DRY
10/29/2003	1	OPEN RANGE	1135	1158	23	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
10/29/2003	1	OPEN RANGE	1158	1342	104	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/29/2003	1	OPEN RANGE	1342	1406	24	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
10/29/2003	1	OPEN RANGE	1406	1410	4	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	REPLACED BATTERY	NA	NA	HOT	DRY
10/29/2003	1	OPEN RANGE	1410	1500	50	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/29/2003	1	OPEN RANGE	1500	1515	15	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	MEMORY DISK FULL	NA	NA	HOT	DRY
10/29/2003	1	OPEN RANGE	1515	1528	13	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
10/29/2003	1	OPEN RANGE	1528	1613	45	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/29/2003	2	OPEN RANGE	1613	1640	27	SETUP/MOBILIZATION	EQUIPMENT BREAKDOWN EOD	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	0650	0730	40	SETUP/MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	0730	0735	5	COLLECTING DATA	SIX-LANE CALIBRATION WITH BOLTS	GPS	LINER	HOT	DRY
10/30/2003	2	OPEN RANGE	0735	0745	10	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
10/30/2003	2	OPEN RANGE	0745	1015	150	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/30/2003	2	OPEN RANGE	1015	1055	40	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1055	1105	10	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1105	1225	80	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/30/2003	2	OPEN RANGE	1225	1229	4	DOWNTIME DUE TO EQUIP MAINT/CHECK	REPLACED BATTERY	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1229	1320	51	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/30/2003	2	OPEN RANGE	1320	1335	15	DOWNTIME DUE TO EQUIP MAINT/CHECK	MEMORY DISK FULL	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1335	1425	50	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/30/2003	2	OPEN RANGE	1425	1429	4	DOWNTIME DUE TO EQUIP MAINT/CHECK	REPLACED BATTERY	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1429	1440	11	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHECKING/ DOWNLOADING DATA	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1440	1535	55	COLLECTING DATA	RUNNING OPEN RANGE NORTH/ SOUTH	GPS	LINER	HOT	DRY
10/30/2003	2	OPEN RANGE	1535	1645	70	SETUP/ MOBILIZATION	EQUIPMENT BREAKDOWN EOD	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	0645	1118	273	DOWNTIME DUE TO EQUIPMENT FAILURE	SOFTWARE PROBLEM	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1118	1142	24	SETUP/MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1142	1335	113	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/30/2003	2	OPEN RANGE	1335	1344	9	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	REPLACED BATTERY	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1344	1517	93	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
10/30/2003	2	OPEN RANGE	1517	1525	8	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	REPLACED BATTERY	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1525	1534	9	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/30/2003	2	OPEN RANGE	1534	1539	5	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	CHECKING/ DOWNLOADING DATA	NA	NA	HOT	DRY
10/30/2003	2	OPEN RANGE	1539	1638	59	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
10/30/2003	2	OPEN RANGE	1638	1645	7	SETUP/ MOBILIZATION	EQUIPMENT BREAKDOWN EOD	NA	NA	HOT	DRY
11/03/2003	2	YUMA EXTREME	0625	0705	40	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/03/2003	2	YUMA EXTREME	0705	0708	3	COLLECTING DATA	SIX LANE CALIBRATION WITH BOLTS	GPS	LINER	COOL	DRY
11/03/2003	2	YUMA EXTREME	0708	0800	52	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/03/2003	2	YUMA EXTREME	0800	1030	150	COLLECTING DATA	RUNNING YUMA EXTREME NORTH/SOUTH	GPS	LINER	COOL	DRY
11/03/2003	2	YUMA EXTREME	1030	1035	5	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	SWAPPED OUT BATTERY	NA	NA	COOL	DRY
11/03/2003	2	YUMA EXTREME	1035	1105	30	BREAK/LUNCH	BREAK	NA	NA	COOL	DRY
11/03/2003	2	YUMA EXTREME	1105	1339	154	COLLECTING DATA	RUNNING YUMA EXTREME NORTH/SOUTH	GPS	LINER	COOL	DRY
11/03/2003	2	YUMA EXTREME	1339	1344	5	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	REPLACED BATTERY	NA	NA	COOL	DRY
11/03/2003	2	YUMA EXTREME	1344	1408	24	BREAK/LUNCH	LUNCH	NA	NA	COOL	DRY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
11/03/2003	2	YUMA EXTREME	1408	1600	112	COLLECTING DATA	RUNNING YUMA EXTREME NORTH/SOUTH	GPS	LINER	COOL	DRY
11/03/2003	2	YUMA EXTREME	1600	1635	35	SETUP/ MOBILIZATION	EQUIPMENT BREAKDOWN EOD	NA	NA	COOL	DRY
11/04/2003	2	MOGUL AREA	0630	0650	20	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/04/2003	2	MOGUL AREA	0650	0657	7	COLLECTING DATA	SIX-LANE CALIBRATION WITH BOLTS	GPS	LINER	COOL	DRY
11/04/2003	2	MOGUL AREA	0657	0725	28	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/04/2003	2	MOGUL AREA	0725	0950	145	COLLECTING DATA	RUNNING MOGUL AREA NORTH/SOUTH	GPS	LINER	COOL	DRY
11/04/2003	2	MOGUL AREA	0950	0955	5	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	SWAPPED OUT BATTERY	NA	NA	COOL	DRY
11/04/2003	2	MOGUL AREA	0955	1016	21	BREAK/LUNCH	BREAK	NA	NA	COOL	DRY
11/04/2003	2	MOGUL AREA	1016	1120	64	COLLECTING DATA	RUNNING MOGUL AREA NORTH/SOUTH	GPS	LINER	COOL	DRY
11/04/2003	2	MOGUL AREA	1120	1255	95	COLLECTING DATA	RUNNING MOGUL AREA EAST/WEST	GPS	LINER	COOL	DRY
11/04/2003	2	MOGUL AREA	1255	1300	5	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	REPLACED BATTERY	NA	NA	COOL	DRY
11/04/2003	2	MOGUL AREA	1300	1330	30	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHECKING/DOWNLOADING DATA	NA	NA	COOL	DRY
11/04/2003	2	MOGUL AREA	1330	1400	30	BREAK/LUNCH	LUNCH	NA	NA	COOL	DRY
11/04/2003	2	CALIBRATION LANE	1400	1450	50	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/04/2003	2	CALIBRATION LANE	1450	1542	52	COLLECTING DATA	RUNNING CALIBRATION LANE EAST/WEST	GPS	LINER	COOL	DRY
11/04/2003	2	CALIBRATION LANE	1542	1620	38	SETUP/ MOBILIZATION	EQUIPMENT BREAKDOWN EOD	NA	NA	COOL	DRY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
11/05/2003	2	OPEN RANGE	0635	0700	25	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/05/2003	2	OPEN RANGE	0700	0709	9	COLLECTING DATA	SIX-LANE CALIBRATION WITH BOLTS	GPS	LINER	COOL	DRY
11/05/2003	2	OPEN RANGE	0709	0720	11	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/05/2003	2	OPEN RANGE	0720	0933	133	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	COOL	DRY
11/05/2003	2	OPEN RANGE	0933	0938	5	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	REPLACED BATTERY	NA	NA	COOL	DRY
11/05/2003	2	OPEN RANGE	0938	1000	22	BREAK/LUNCH	BREAK	NA	NA	COOL	DRY
11/05/2003	2	OPEN RANGE	1000	1041	41	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/05/2003	2	OPEN RANGE	1041	1051	10	COLLECTING DATA	SIX-LANE CALIBRATION WITH BOLTS	GPS	LINER	COOL	DRY
11/05/2003	2	OPEN RANGE	1051	1155	64	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
11/05/2003	2	OPEN RANGE	1155	1220	25	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	CHECKING/DOWNLOADING DATA	NA	NA	HOT	DRY
11/05/2003	2	OPEN RANGE	1220	1310	50	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
11/05/2003	2	OPEN RANGE	1310	1440	90	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
11/05/2003	2	OPEN RANGE	1440	1515	35	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	CHECKING/DOWNLOADING DATA	NA	NA	HOT	DRY
11/05/2003	2	YUMA EXTREME	1515	1520	5	SETUP/MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
11/05/2003	2	YUMA EXTREME	1520	1612	52	COLLECTING DATA	RUNNING YUMA EXTREME NORTH/SOUTH	GPS	LINER	HOT	DRY
11/05/2003	2	YUMA EXTREME	1612	1625	13	SETUP/MOBILIZATION	EQUIPMENT BREAKDOWN EOD	NA	NA	HOT	DRY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
11/06/2003	2	OPEN RANGE	0630	0645	15	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/06/2003	2	OPEN RANGE	0645	0650	5	COLLECTING DATA	SIX- LANE CALIBRATION WITH BOLTS	GPS	LINER	COOL	DRY
11/06/2003	2	OPEN RANGE	0650	0730	40	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/06/2003	2	OPEN RANGE	0730	0920	110	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	NA	COOL	DRY
11/06/2003	2	OPEN RANGE	0920	0956	36	BREAK/LUNCH	BREAK	NA	NA	COOL	DRY
11/06/2003	2	CALIBRATION PIT	0956	1037	41	SETUP/ MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	COOL	DRY
11/06/2003	2	CALIBRATION PIT	1037	1102	25	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON 155 MM	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1102	1109	7	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON ATC 105 MM	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1109	1115	6	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON 105 MM	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1115	1120	5	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON 81 MM	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1120	1125	5	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON 2.75 INCH	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1125	1135	10	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON MK 118	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1135	1141	6	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON 60 MM	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1141	1148	7	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON 57 MM	GPS	LINER	HOT	DRY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
11/06/2003	2	CALIBRATION PIT	1148	1156	8	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON BDU 28	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1156	1202	6	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON 40 MM	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1202	1206	4	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON BLU-26	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1206	1214	8	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON M 42	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1214	1220	6	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON 20 MM	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1220	1226	6	COLLECTING DATA	RUNNING SIGNATURE DATA NORTH/SOUTH ON M 385	GPS	LINER	HOT	DRY
11/06/2003	2	CALIBRATION PIT	1226	1310	44	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHECKING/DOWNLOADING DATA	NA	NA	HOT	DRY
11/06/2003	2	OPEN RANGE	1310	1315	5	SETUP/MOBILIZATION	SETTING UP EQUIPMENT FOR TESTING	NA	NA	HOT	DRY
11/06/2003	2	OPEN RANGE	1315	1330	15	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
11/06/2003	2	OPEN RANGE	1330	1347	17	DOWNTIME DUE TO EQUIPMENT FAILURE	LOST GPS	NA	NA	HOT	DRY
11/06/2003	2	OPEN RANGE	1347	1352	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT BATTERY	NA	NA	HOT	DRY
11/06/2003	2	OPEN RANGE	1352	1423	31	COLLECTING DATA	RUNNING OPEN RANGE NORTH/SOUTH	GPS	LINER	HOT	DRY
11/06/2003	2	OPEN RANGE	1423	1540	77	DEMOBILIZATION	END OF TEST	NA	NA	HOT	DRY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

APPENDIX E. REFERENCES

1. Standardized UXO Technology Demonstration Site Handbook, DTC Project No. 8-CO-160-000-473, Report No. ATC-8349, March 2002.

2. Aberdeen Proving Ground Soil Survey Report, October 1998.

3. Data Summary, UXO Standardized Test Site: APG Soils Description, May 2002.

4. Yuma Proving Ground Soil Survey Report, May 2003.

5. Practical Nonparametric Statistics, W.J. Conover, John Wiley & Sons, 1980, pages 144 through 151.

APPENDIX F. ABBREVIATIONS

AEC	=	U.S. Army Environmental Center
APG	=	Aberdeen Proving Ground
ASCII	=	American Standard Code for Information Interchange
ATC	=	U.S. Army Aberdeen Test Center
ATSS	=	Aberdeen Test and Support Services
BAR	=	bit aspect ratio
CD	=	compact disc
CEP	=	Central Error Probability
DGPS	=	differential Global Positioning System
EM	=	electromagnetic
EMF	=	electromagnetic force
EMU	=	electromagnetic unit
ERDC	=	U.S. Army Corps of Engineers Engineering Research and Development Center
ESTCP	=	Environmental Security Technology Certification Program
EQT	=	Army Environmental Quality Technology Program
GPS	=	Global Positioning System
GX	=	Geosoft executable
HEAT	=	high-explosive, antitank
HERO	=	hazards of electromagnetic radiation to ordnance
JPG	=	Jefferson Proving Ground
LLC	=	Limited Liability Company
METDC	=	Military Environmental Technology Demonstration Center
MS	=	Microsoft
NS	=	non-standard
POC	=	point of contact
QA	=	quality assurance
QC	=	quality control
RF	=	radio frequency
RH	=	relative humidity
RMS	=	root mean square
ROC	=	receiver-operating characteristic
RTK	=	real-time kinematic
SERDP	=	Strategic Environmental Research and Development Program
SI	=	International System
UXO	=	unexploded ordnance
YPG	=	U.S. Army Yuma Proving Ground

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